natural hazards may have actually increased the danger posed by more extreme disasters—may elicit some controversy. He said the facts are incontrovertible, though: that the costs of natural hazards in the United States has averaged about $1 billion per week since 1989 and is expected to keep rising.

The federal government, said U.S. Geological Survey (USGS) Deputy Director Thomas Casadevall, too often in the past has played a paternalistic role in how it informs people about disasters and mitigation or relief efforts. He said the study "validates the concept that we citizens have a role to play in the choices we make about where we live, where we work, where we play, and recognize that there are situations that might threaten life or limb."

Casadevall said his agency is trying to involve and work closely with local communities in many of its programs, and also is trying to integrate its expertise in an interdisciplinary approach in order to address the complex nature of natural disasters.

Jane Bullock, chief of staff for the Federal Emergency Management Agency (FEMA), commented that the report affirms recent moves by the agency to respond to disasters. "That movement is toward making people recognize that they have a level of responsibility that they must take, but also recognize that they do not have to be victims of disasters and that we can break the damage, repair, damage, repair cycle" that in the past has inadvertently encouraged reconstruction in harm's way. Bullock said the agency's Project Impact, now active in more than 118 U.S. communities, stresses building disaster-resistant communities. In addition, she said the FEMA program of buying property that is in harm's way from willing sellers has reaped significant benefits in terms of lessened losses from natural hazards.

The 5-year, $750,000 study to reassess natural hazards examined natural disasters from 1975-1994. The study, which is a follow-up to a 1975 assessment of the U.S. ability to withstand natural hazards, was funded primarily by NSF's engineering directorate, with contributions from FEMA, USGS, the U.S. Forest Service (USFS), and the U.S. Environmental Protection Agency.

For further information about the report, "Natural Hazards and Disasters: Reducing Loss and Building Sustainability in a Hazardous World," visit the National Academy Press Web site: http://www.nap.edu, or call 1-800-624-6242. For further information about the Natural Hazards Research and Applications Information Center and its publications, visit the Web site: http://www.colorado.edu/hazards.

Randy Showstack, Staff Writer

BOOK REVIEWS

Isotope Geochemistry Researches in China

PAGE 260

Guangzhi Tu and T. J. Chow (Eds.), Science, New York, 590 pp., ISBN 1-880132-33-8, 1998, $180.

The publication of *Isotope Geochemistry Researches in China* represents a major milestone in such research in China. Every isotope geochemist will find at least one informative article in his or her own field of interest in this large and comprehensive volume.

The book is divided into 27 chapters, written by 41 authors, and the scope, content, and quality of the chapters are variable. In general, each is a review or an overview of a topic in geochemistry. Some of the chapters are very short and provide only a very general overview. Others are long and provide a detailed and more comprehensive review of a specific subject. Most are translated into English and they are generally professionally done. The quality of the figures and tables varies, but most are clear and informative. An extensive, current bibliography (some in Chinese publications) is provided at the end of the book for each chapter, but there is no index. To help readers find the localities of the areas studied, a table is appended containing names in English and Chinese with latitude and longitude, but no map is included.

The book begins with an introduction to the divisions and nomenclature of a new chronological timescale of China with over 100 reference points and boundary ages from the Early Archean to the Tertiary. Then a chapter on Precambrian chronology includes an interesting discussion on the chronology of the oldest rocks in China. Detailed ionmicroprobe U-Pb age determinations on zircon support the existence of a sialic continental crust at 3.8 x 10^9 years ago in present Hebei and Liaoning Provinces.

A short overview of Mesozoic and Cenozoic volcanism in eastern China is limited to geochronology. The subsequent chapter on marine sulfur and carbon isotope research is very extensive and includes many detailed stratigraphic sections. A brief review of Quaternary geology includes terrestrial (loess) facies strata, salt lake sediments, peat and human fossils (Peking man).

Four well-written chapters summarize the regional geology and tectonics of four selected study areas—the Yangtze and the Huanan Block in the southeast; the Xinjiang Uygur autonomous region in the northwest; the Qinling-Dabie orogenic belt in the central region; and the Qinghai-Tibet plateau in the southwest. The authors use multi-isotopic systematics (Sm-Nd, Rb-Sr, K-Ar and U-Pb) and combine petrologic, geochemical, and isotopic data to address complex petrologic-tectonic problems in these regions. Readers are led from a brief introduction and a review of the problems to applications of isotopic data to each of the specific study areas and a summary or a tectonic model at the end of each chapter. For example, the Qinling-Dabie discussion is a long and comprehensive article on the problems of dating a few, rare, ultrahigh-pressure metamorphic rocks from the Dabie Mountain and the Su-Lu terrain. Extensive work has been carried out on these rocks by researchers from China and other parts of the world. Because of the low content of radioactive trace elements in eclogite minerals and the complicated thermal and tectonic history of this region, it is quite a challenge to determine the detailed chronology of this orogenic belt—the ages of the protoliths, the times of peak and retrograde metamorphism, and the retrograde P-T-t path.

Also covered is the isotope geochemistry of granitoids which occupy about 30% of the bedrock in China. Examples of the main granitoids in China are reviewed in terms of the ages of formation, their source materials and characteristics, and their formation conditions. A multiple-isotopic-component mixing model is presented next for the evolution of the continental crust and upper mantle and an interpretation of the isotopic data from China. Marine isotope geochemistry is also taken up, with brief reviews of ^{210}Pb profiles and deposition rates of coastal sediments, Quaternary coastline migration, sea level changes, and Sr-Pb-C-O isotopic compositions in South China Sea sediments.

A comprehensive review of the isotopic geochemistry of some economically and strategically important deposits (W, Sn, U, Au, Fe, Cu, Pb-Zn and kaolin) in China comes next. Before flagging through these 160 pages, however, readers may want to read Chapter 21, which provides helpful comments on isotope geochemistry as related to mineral deposits in China. The author, Guangzhi Tu, gives his view on the origin and classification of some of the ore deposits in China and presents the concept of polygenesis. He also cautions against the wide use of the plumbotectonic model, introduced in 1981 by R. E. Zartman and B. R. Doe in explaining the sources of lead.

Also dealt with are biochemical reactions and the stable isotope geochemistry of fossil fuels: petroleum and natural gas reservoirs, and coal reserves. A discussion of meteoric waters summarizes mainly the influence of the Monsoon climate on the seasonal and geographical distribution of isotopic compositions of precipitation in eastern China at present and in the past. Another informative

review of the stable isotope geochemistry of underground salt brines also is given. In the final chapter, the authors give a brief summary of the isotopic compositions of noble gases in natural gases, volcanic gases and hot springs, and gases from seismic activity. That chapter also includes a brief review of helium isotopes in seawater and provides an explanation for the excess ^{3}He in the western Pacific.

About half of the book concerns isotopic research in various aspects of economic and environmental geology, which reflects the national emphasis in these fields in the last 20 to 30 years. The study areas cover most of China except the north and northeast. The high quality of data indicates that almost all available modern analytical techniques for both stable and radiogenic isotopic measurements are now well-established in China. Lacking are high precision U-series, U and Th isotopic data by either α-counting or mass spectrometry techniques; Lu-Hf isotopic data, and Re-Os, Cl and B isotopic data by mass spectrometry technique. In addition, most of the petrogenesis discussions are limited to the isotopic systematics and involve few major and trace element abundance patterns. This may be simply because of the long preparation time for this volume and the limitation on the length of the chapters. As E. D. Goldberg comments in the introduction, this book represents only a very small sampling of the research being carried out in China in the last few decades.

The book contains a wealth of valuable information and high quality data on contemporary isotope geochemistry research in China. Generally it is well produced. For anyone interested in these research areas in China, it is now the single most valuable reference volume on the subject.

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Isotope Tracers in Catchment Hydrology

PAGE 260

C. Kendall and J. J. McDonnell (Eds.), Elsevier Sci., New York, xxix + 839 pages, ISBN 0-444-50155-X, 1998, $91.

The drainage basin has been a fundamental unit of study in hydrology and geomorphology throughout the modern era of these Earth sciences. The basin, or catchment, is a convenient unit because it typically is well defined topographically, can be studied as a series of nested units of increasing size, and is an open system for which inputs and outputs of mass and energy can be defined and measured. Small catchments have been the "outdoor laboratories" for hydrologists interested in rainfall-runoff relationships, for geochemists interested in the export of weathering products from the landscape, and for ecosystem ecologists interested in biogeochemical cycling.

Research studies on small catchments have evolved from a strong focus on strictly input-output relationships (a "black-box" approach) to a focus on understanding flow paths, residence times, and biological and chemical reactions within the catchment. Tracers are essential tools for such work. In catchment studies, tracers that move with the water but do not interact with biota, soils, and rocks are sought so that water itself can be followed. Other tracers are used to follow selected biogeochemical reactions. A multitude of stable and radioactive isotopes has been used as tracers in catchment studies.

In *Isotope Tracers in Catchment Hydrology*, editors Carol Kendall and Jeff McDonnell have assembled 22 chapters that cover a wide range of topics related to the use of isotope tracers in catchment studies. (In fact there is good coverage of some topics not typically considered to be in the realm of catchment hydrology, such as lake evaporation and groundwater recharge.) A chapter reviewing the basics of isotope geochemistry is extremely valuable for someone from the physical hydrology side of the house—like me! A suite of chapters on processes (such as isotopic fractionation in snow), on hydrological case studies (such as arid catchments), on geochemical case studies (such as nitrogen cycling), and on synthesis (such as modeling hydrogeochemical responses) form the core of the book.

As I launched into this book, I admit I had some concern that I would find authors overly euphoric about what could be done with tracers. Users of particular tools often are so taken with the techniques that they become effective, if not always impartial, salespersons. My worry was not assuaged when I read "... why do environmental hydrogeologists continue to under utilize isotopes?" (One answer given—"fear of the unknown"—was enough to make me cringe.) Any fears that I had were dispelled on reading the book, however. The material presented is thorough both in showing the power of using isotope tracers and in exposing the difficulties.

When tracers are used to infer flow paths and residence times in a catchment, a model of the hydrological system is required. That is, the data are used in an inverse solution to infer parameters of the underlying conceptual model, which may be a simple two-component mixing model or may be much more complex. Problems arise because the proper model may not be known, because the inverse solution may not be unique, and because data may not be adequate to constrain the solution.

The most striking result of isotope studies of catchment hydrology over the past several decades is the large and often dominant role of subsurface water in generating stream runoff in humid headwater catchments. This is a result inferred by assuming a two-component (sometimes three-component) mixing model.

Going beyond this now well established result has proven to be much more problematic. Inverting more complex models requires careful and detailed hydrometric measurements as well as measurements of isotope tracers. The problems of spatial heterogeneity that are so prevalent in all of hydrology are realized in tracer studies under these conditions. Answers to the problems are not straightforward and will require new research. This book convinces one that a host of clever scientists are using isotope tracers effectively to address complex problems in catchment science but that many problems must be resolved before worrying about "under-utilization of isotopes."

Each chapter is authored by one or more individuals who have devoted much professional effort to understanding catchment processes using isotope tracers as a tool. Thus, the chapters uniformly are authoritative. Kendall and McDonnell also have done an excellent job minimizing chapter-to-chapter inconsistency that often plagues compilations of papers. The chapters follow a similar template and, for the most part, do not have gratingly different styles. Almost all of the chapters are well worth reading, and many will surely become required reading in graduate courses around the world.

The editors have used the term hydrology in its broadest sense—to include the waters of the Earth and all interactions with Earth materials and ecosystems. The book provides a wealth of information not just for those with an interest in physical hydrology but for geochemists and ecologists as well. It will be a valuable addition to the library of scientists in all of the disciplines engaged in catchment studies.

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